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THE LOWER HURONIAN ICE AGE

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INTRODUCTION

When geologists slowly became convinced of the reality of the Pleistocene glacial period it was held to be a unique catastrophe belonging to the later history of a cooling world, something without precedent in earlier geological epochs. Then, reluctantly and with astonishment, a Permo-Carboniferous glacial period, even more tremendous than that of the Pleistocene, was admitted as proved. Later still, an extensive ice age in early Cambrian or late pre-Cambrian times has been demonstrated, carrying back continental glaciers to the beginning of known life in the world.

For a number of years it has been my belief that a still earlier glacial period was the cause of the widespread basal conglomerate of the Lower Huronian; and last year, when a few scratched stones were obtained from this conglomerate at the silver-mining region of Cobalt, it seemed worth while to show that a Lower Huronian ice age was highly probable.¹

During the past summer fresh material has been collected in the Cobalt region, including some well-preserved "soled" bowlders with ice-smoothed surfaces and well-marked striae, removing all doubt of the glacial origin of the conglomerate; and it is proposed to present here the evidence for this most ancient of known ice ages.

THE STONES OF THE BOWLDER CLAY

It requires patience to separate the pebbles and bowlders from the hard matrix of the conglomerate, or tillite, to use Penck's term, and no very large number have been extracted, but most of them have the characteristic subangular forms of glaciated stones. As illustrations, two photographs are reproduced, the largest stone represented being about eight inches across, and having good striae on both sides and in more than one direction, one set crossing another. If the speci-

¹ *American Journal of Science*, Vol. XXIII, March, 1907.

mens collected were mixed with Pleistocene boulder clay they could hardly be distinguished from the other stones in the clay unless perhaps by lacking the polish found on some from the Pleistocene. When it is remembered that the Lower Huronian tillite has undergone mountain-building stresses and a certain amount of metamorphism, it is astonishing to find the striations so perfectly preserved,



FIG. 1.—Lower Huronian “soled” boulder with striations in several directions.

especially in the absence of limestone and slate pebbles, which afford the best marked glaciated stones of the Pleistocene. In the Lower Huronian tillite, felsites and fine-grained greenstones show the striae best. The illustrations given are of greenstones.

The types of rock observed are granite, gneiss, massive greenstone, green schist, felsite, and banded chert or jasper of the iron formation; all found in place in the underlying Keewatin and Laurentian, the only older formations existing in the localities. The granites are of at least three kinds, and include most of the larger boulders, one

which was measured reaching diameters of $5 \times 3 \times 3$ feet; but the largest boulder seen, near Temagami station, was of greenstone showing pillow structure, having diameters of 8×5 ft. as exposed on an ice-smoothed surface. Many of these boulders are several tons in weight and some of the granites are miles away from the nearest known source. The smaller pebbles of felsite often show exactly the same subangular shapes with irregular well-polished surfaces as are found on pebbles of fine-grained rock in later boulder clays.



FIG. 2.—Lower Huronian “soled” boulder.

In many parts of the tillite the stones are sparsely distributed, sometimes several feet or even yards apart, and the red granites stand out sharply from the green-gray ground-mass. Such parts of the conglomerate present exactly the characters of till or ground moraine.

THE MATRIX OF THE BOWLDER CLAY

The matrix of the tillite is generally graywacke, fine grained, but containing small angular particles of quartz and feldspar. It shows no stratification as a rule, though the rock as a whole may have a rude banding, pebbles and boulders being more numerous in some layers than in others. In the original Huronian region, as described by Murray and Logan, the matrix was called slate, the rock being

referred to as "slate conglomerate," but some varieties of it were described as like quartzite or diorite or greenstone. In fact, the rock not seldom looks so massive in the field that it might easily be taken for a fine-grained basic eruptive, if it were not for the red granite boulders scattered here and there through it; and some geologists have thought it a tuff or volcanic breccia, just as the Dwyka in South Africa was at first explained.

In reality, of course, till consists of the more or less finely ground materials of the rocks over which the ice sheet passed. If it traversed

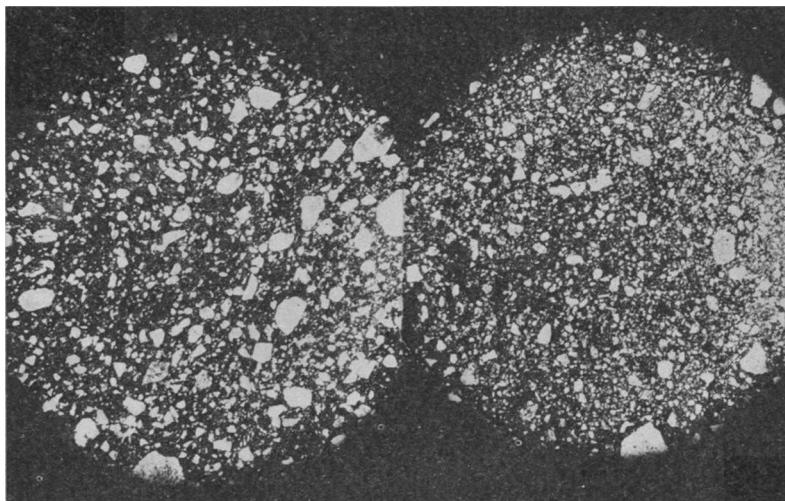


FIG. 3.—Thin sections of matrix of boulder clays. Dwyka to the left, Lower Huronian to the right.

granite, the clayey substratum would be mixed with grains of feldspar and quartz; if it passed over fine-grained greenstones, the particles might suggest an ash rock; if the two materials were mixed, as must have been the case when the Lower Huronian glaciers moved over a surface of Keewatin penetrated by Laurentian granite and gneiss, the resulting boulder clay would have the composition which we actually find.

The sections from near Cobalt show a small amount of very fine-grained turbid material, in which a few scales of chlorite can be recognized, crowded with angular bits of quartz, orthoclase and plagi-

clase of all shapes and sizes, and with some larger rock fragments such as diabase porphyrite or felsite or porphyritic felsite. A section from near Thessalon, north of Lake Huron, has essentially the same composition, but the minerals have been a little more rearranged.

For comparison, thin sections of the Dwyka matrix were studied, and were found to be surprisingly like those mentioned above; the only noticeable difference being the absence of chlorite scales, and a somewhat darker and less translucent ground-mass. These slight differences are no doubt due to the fact that the Dwyka conglomerate, being much younger, has undergone less rearrangement. In the illustrations the great resemblance of the two boulder clays is shown, though by chance a rather fine-grained part of the Cobalt thin section was photographed.

COMPARISON WITH LATER GLACIAL DEPOSITS

While much of the Lower Huronian conglomerate has the character of till, there are also phases made up almost wholly of coarse materials, boulders, pebbles, and smaller bits of rock, with very little of the finer matrix representing clay; and these may be compared with terminal-moraine stuff.

On the other hand, the tillite sometimes passes into stratified slate with only here and there a boulder or with no boulders at all. In one case a boulder nearly a foot thick was seen with the stratification bending round it as though it had been dropped into mud from floating ice.

Beside the distinctly till-like and morainic varieties of the gray-wacke conglomerate there are sometimes bands of crowded pebbles somewhat assorted as to size, well rounded, and no doubt water formed, corresponding to the kame materials of Pleistocene deposits. Where stratified conglomerate beds or thinly bedded slates lie between sheets of unstratified tillite, we may safely compare them with the interglacial beds of stratified sand and gravel between layers of till found at Scarboro Heights, for instance.

The known thickness of the conglomerate including the other phases mentioned is about 500 feet as measured by Professor Miller at Cobalt, which may be compared with the 400 feet of drift deposits at Scarboro near Toronto.

From the outline just given it will be seen that every feature of the Lower Huronian rocks has its close parallel in the complex of boulder clays and sediments of the Pleistocene, though the latter are, of course, loose and unconsolidated. A comparison with the Dwyka conglomerate of Permo-Carboniferous times is more convincing still, since the Dwyka is now solid rock. Hand specimens of the two tillites might easily be interchanged by one not familiar with them. Specimens from Matjesfontein in Cape Colony or N'gotsche Mountain in



FIG. 4.—Polished pebbles in ancient till. Dwyka to left, Lower Huronian to right.

Natal placed beside specimens from Cobalt or north of Lake Huron present the same fine-grained gray matrix with angular bits of quartz and feldspar, or fragments of granite, or small polished pebbles of felsite. As shown before, even thin sections under the microscope present no material differences.

In fact, the only important point of distinction between the two tillites is the comparative ease with which the Dwyka matrix weathers, setting free the inclosed stones; while in the Cobalt rock matrix and pebbles weather at nearly the same rate. In both tillites when fresh it is hard to break out the stones by the hammer, since the fractures

are apt to run impartially through pebble and matrix. One cannot but be struck by the close resemblance the two rocks have to one another in every particular. Every argument which goes to prove the glacial origin of the Dwyka conglomerate applies equally well to the Lower Huronian conglomerate of northern Ontario, with one exception.

No underlying striated surfaces or *roches moutonnées* have been found beneath the Lower Huronian tillite; while beautifully glaciated surfaces are displayed beneath the northern Dwyka. It should be remembered, however, that no such surfaces have been found under the southern Dwyka, where the conglomerate passes downward into



FIG. 5.—Dwyka tillite to left, Lower Huronian to right.

shale, e. g., near Matjesfontein. It may be recalled also that at many points in North America no ice-smoothed surfaces are found under Pleistocene boulder clay. This is the case at Toronto, where the underlying Hudson shale is never polished or striated but seems almost to blend upward into the lowest sheet of boulder clay. The absence so far as known of *roches moutonnées* under the Lower Huronian conglomerate is then no valid argument against its glacial origin.

EXTENT OF THE LOWER HURONIAN GLACIATION

The striated stones referred to earlier in this paper were obtained at two points three or four miles apart, in a cutting on the Temis-

caming railroad near mile 100, and on the Trethewey silver-mining location; both localities being included in the same area of conglomerate as mapped by Professor Miller. Search was made for glaciated stones near Temagami, twenty-eight miles southwest, where the conglomerate is prominent in railway cuttings, but the rock proved to be somewhat squeezed and decidedly more metamorphosed than at Cobalt, so that the stones broken out of the matrix showed no well-preserved surfaces. In every other respect the conglomerate is exactly like that of the silver region.

Conglomerates of the same age are known from almost every area mapped as Huronian in Ontario, from Lake Temiscaming on the east to Lake-of-the-Woods on the west, a distance of more than 700 miles; and from Lake Huron on the south to the north end of Lake Nipigon, 250 miles. In my own field-work such conglomerates have been studied at more than twenty localities scattered over the great region.

In most cases the conglomerate has proved to be far more metamorphosed than at Cobalt, often transformed into schist conglomerate with the pebbles and boulders flattened into lenses. In such cases the resemblance to boulder clay is lost, though the varied size and lithographical characters of the stones, and often also their wide spacing in the matrix, are suggestive of a glacial origin.

In several places, however, the Lower Huronian conglomerate is almost as unchanged as at Cobalt, for instance, near Lake Wahnapitae, east of Sudbury, and at various places in the typical Huronian region north of Lake Huron. Years ago these impressed me as resembling boulder clay, but at that time no striated stones were found.

These areas of characteristic tillite occur at points 200 miles apart, about in lat. 46° . Of the other conglomerate areas one can only say that in all probability they are glacial also. In some places where the pebbles form closely crowded bands and are fairly uniform in size they are probably water formed, and may be explained as kames or marginal gravel beds like the Saskatchewan gravels of Alberta, glacial materials rearranged by rivers or by wave action.

Very similar boulder conglomerates are described from Huronian regions not visited by the present writer. Dr. Bell maps schist conglomerates in northern Quebec, the most easterly at Mattagami Lake, in long. $77^{\circ} 30'$, and Mr. Low describes boulder conglomerates from

southern Labrador. Mr. J. B. Tyrrell has found them on Pipestone and Cross lakes northeast of Lake Winnipeg, in long. $97^{\circ} 30'$, and Mr. Stewart Dobbs has described them from Manitou River near Hudson Bay, in lat. 57° and long. 92° . Huronian conglomerates exist, then, at points 1,000 miles apart from east to west and 750 miles apart from south to north; and there is little doubt that areas still remain to be discovered in the far north. To the south of the Great Lakes very similar Lower Huronian conglomerates are known in Minnesota and Michigan, and it is altogether probable that other areas to the south are buried beneath the Paleozoic sediments. Supposedly Huronian conglomerates have been described also from the Avalon Peninsula of Newfoundland.

So far as North America is concerned the probable extent of glaciated territory is comparable to that of the Permo-Carboniferous and the Pleistocene. In the Old World also there are very ancient boulder conglomerates which may be of the same age and origin. Sir Archibald Geikie says of such boulder beds in Scotland that, "where the component blocks are large and angular, as at Gairlock, they remind the observer of the stones in a moraine or in boulder clay."¹ Similar pre-Cambrian conglomerates are found in Scandinavia and in Finland; and probably also in India and China; but whether they are equivalent in age to the Lower Huronian of Canada is uncertain.

GENERAL CONCLUSIONS

It has been shown that convincing evidence of glacial action in Lower Huronian times has been found in the Cobalt region of northern Ontario, the glaciated stones obtained there furnishing the final proof; that exactly similar conglomerates occur at points 50 and 200 miles farther west, though no striated stones have yet been found in them; and that boulder conglomerates, once probably of the same kind, but now squeezed and rendered schistose, occur in every important tract of Huronian in North America, suggesting strongly that the whole region was glaciated at that time.

Moved by conservatism and having in mind the long-accepted theory of a molten earth slowly cooling to its present temperatures, some geologists may object to the conclusions given above and may think that too much stress has been put on the few scratched boulders

¹ *Text Book of Geology*, p. 705.

thus far obtained. In reply it may be stated that the striated stones are merely the climax of the evidence in favor of a Lower Huronian ice age. The character and extent of the conglomerates themselves are unaccountable on any other theory. If these conglomerates were known only from a few small patches, one might perhaps invoke crushing and faulting, or talus formation, or exceptionally heavy river currents to account for them; but when one finds that they often cover many square miles, with thicknesses of hundreds or even more than a thousand feet, and occur in every Huronian district with the same characteristics, any such cause becomes incredible. It must be remembered that, large as the conglomerate areas are, they represent only remnants of a much more widely spread formation; for the greater part they are merely bands caught in synclines during the elevation of the Archaean mountain ranges. In the beginning the conglomerate must have been far more extensive and was perhaps continuous over the hundreds of thousands of square miles where it is now found in scattered patches. The only comparable boulder-bearing formations known are the boulder clays of Permo-Carboniferous and Pleistocene times. Under these circumstances the burden of proof lies with those who oppose the glacial origin of the Lower Huronian conglomerate, and not with those who support it.

Since there is only one older sedimentary formation, the Keewatin, below the Lower Huronian, the glacial period just described comes very close to the beginning of known geological history. The surface of North America was much colder then than at present, and there is every reason to think that the earth's climates were then, as now, controlled from without, and not influenced by stores of internal heat much greater than in recent times. The earth has not cooled down from the earliest ages known to geology, but may have kept a uniform temperature, or may have been warming up as the ages advanced.

If a Lower Huronian ice age is admitted, geologists should cease to speak of the earth as once a molten globe, and to begin historical geology with its cooling so as to form a solid crust, on which, much later, water could condense, and sedimentary deposits be formed. There is no geological evidence of any such early history, and we should not cling to an outworn nebular hypothesis which the astronomers themselves are throwing overboard.